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Original Research Article

Prevalence and determinants of digital eye strain among school children during the COVID-19 pandemic

Catherine Simon[1]*, Shalet Paul[2]

[1]Department of Community Medicine, [2]Department of Ophthalmology, Azeezia Institute of Medical Sciences and Research, Kollam, Kerala, India

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***Correspondence:**
Dr. Catherine Simon,
E-mail: kadakath@hotmail.com

ABSTRACT

Background: Digital eye strain (DES) is an emerging public health problem due to continuous exposure to electronic gadgets and digital devices for educational, occupational or entertainment purposes, especially during this COVID-19 pandemic. Children are more vulnerable to DES, as they continue to attend online classes but are unaware of early symptoms of DES and do not complain till their vision deteriorates. The objective of this study was to assess the prevalence and risk factors of DES among school children during this pandemic.
Methods: A questionnaire-based cross-sectional study was conducted among 176 school children aged 12-16 years, studying in 8th, 9th and 10th standards of a randomly selected school in Kollam district of Kerala, using the validated computer vision syndrome questionnaire (CVSQ), sent online via Google form to parents/guardians for recording their children's pattern of digital device usage and DES symptoms.
Results: The prevalence of DES among school children was 29.5%. Their commonest symptom was headache (n=125, 69.9%). The smartphone was the most commonly used digital device (n=159, 93.5%). The independent risk factors of DES were the preferred use of smart phone (adjusted odds ratio (AOR)=2.846; 95% CI=1.371-5.906; p=0.005) and viewing distance of digital device <18 inches (AOR=2.762; 95% CI=1.331-5.731; p=0.006).
Conclusions: This study has highlighted some of the risk factors associated with DES. A concerted effort is needed to raise awareness about DES by experts in the health and education sectors, along with parents and teachers, so that digital device use among children can be optimised.

Keywords: Digital eye strain, Prevalence, School children, Digital devices, COVID

INTRODUCTION

DES is defined by the American optometric association as encompassing a range of visual and ocular symptoms arising due to prolonged use of digital electronic devices.[1] The use of digital devices such as laptops, smartphones, desktops, tab and television, has grown in the last decade due to the massive growth in internet and digital technology.[2] These devices cause harm by emitting short high energy waves that can penetrate the eyes and can eventually contribute to photochemical damage to the retinal cells, making an individual vulnerable to a variety of eye problems ranging from dry eye to age-related macular degeneration.[3] When the demand for near work exceeds the normal ability of the eye to perform the job comfortably, one develops discomfort and the prolonged exposure leads to a cascade of reactions that can be put together as DES.[4]

DES is an emerging public health threat and it is associated with the pattern of digital screen usage. Children routinely spend more time attending e-classes, and in front of a television or mobile screen. The COVID-19 pandemic has necessitated drastic lifestyle changes, one of which is increased exposure to digital devices,

which can cause a wide variety of ocular problems in children. Of this, DES is the most common and characterized by symptoms such as dry eyes, itching, foreign body sensation, watering, blurring of vision and headaches. We are pushing a COHORT of children into a higher risk of DES due to the current trend of unregulated e-learning.[5] The age group that is the most at-risk is school children and it is assumed that their diagnosis could get delayed as they may not complain in the initial stages like adults. This leads to a delay in the diagnosis of DES and makes children most at-risk. The increased use of digital devices by adolescents brings a new challenge of digital eyestrain at an early age.[6] It is therefore of prime importance to identify DES early, especially in children, to prevent DES and its long-term complications.

Objectives

The objectives were to estimate the prevalence of DES among school children during the COVID-19 pandemic and to determine the risk factors associated with DES among the study participants.

METHODS

Study design

The study design was observational cross-sectional study.

Study population

School children in the 8th, 9th and 10th grades of the selected school-Nithya Sahaya Matha girls' high school, Kollam was the study population.

Study duration

Four and a half months (mid-July 2021 to November 2021) was the study duration.

Sample size

The sample size of 176 study participants was calculated as for a cross-sectional study, using the formula,

$$N=\frac{4pq}{d^2},$$

Where,

p was the prevalence of DES taken as 50.23% from another study.[7]

This was to obtain the true prevalence of DES at an allowable error of 15% at 95% CI. Calculation of sample size,

p=prevalence of DES=50.23%; q=100-p=49.77%,

d=allowable error=15% of p=15/100×50.23=7.535.

$$N=\frac{4\times 50.23\times 49.77}{d^2},$$

$$N=\frac{9999.8}{(7.535)^2},$$

$$N=\frac{9999.8}{56.776}=176.$$

Sampling method

One of the four schools in a rural area of Kollam was selected by simple random sampling method. It was a girls' high school, from which the 8th, 9th and 10th classes were chosen by stratified random sampling. There were a total of 474 students in the 8th, 9th and 10th grades of the selected school, out of which 180, 140 and 154 children were studying in the 8th, 9th and 10th classes respectively. From these selected classes, 66, 52 and 58 students respectively were chosen by simple random sampling (lottery method), so that the number of students obtained in each of the 3 selected classes were proportionate to their respective class strength. Thus the required sample size of 176 study participants was obtained.

Inclusion criteria

Students of 8th, 9th and 10th standard of the selected school, who were willing or given permission by parents to participate in the study were included.

Exclusion criteria

Students in the above classes with congenital eye disorders, corneal ulcers or who had undergone intra-ocular eye surgery in the past 6 months were excluded.

Permission from school authorities

Permission had been sought from the school authorities of the selected school to conduct the study. The principal's written letter of authorization had been obtained for the same.

Data collection methods

Before recruitment, an online information sheet regarding the purpose, duration and confidentiality of the study was sent to the parents/guardians through the school WhatsApp group in Google form, so that they could indicate whether they are willing to permit their child/ward to take part in the study. Informed consent was obtained from the parents and those who were willing to take part in the study, accessed the study tool (DESK survey questionnaire), filled in the Google form and returned it online to the investigators.

Study tool

The DES symptoms and its severity were measured using the CVSQ developed by Segui et al.[8] This was a reliable and validated questionnaire that was originally used to study DES at the workplace but have since been used for studying DES among adolescents, high school children as well as college students. The CVSQ had been modified and validated for use in school children and was known as DES for kids (DESK-1) questionnaire.[7]

Data entry and analysis

Data was collected from the respondents via Google form and exported into MS excel sheet. Analysis of data was done using SPSS software version 20.0. Quantitative variables are presented as mean±standard deviation, while qualitative variables were presented as frequency and percentage. In the univariate analysis, the odds ratio, Chi square and Fischer's exact tests were used to assess the association between the qualitative variables and DES. In the multivariate analysis, multiple logistic regression analysis was performed to identify the independent risk factors for DES. A p value <0.05 was considered as statistically significant.

Scoring of DES

The CVSQ evaluated the intensity of DES as (moderate or intense) and frequency (never, occasionally or always/often) of 16 eye-strain related symptoms, including burning sensation, itching of the eyes, foreign body sensation, watering of eyes, excessive blinking, redness, eye pain, heaviness in the eyelids, dryness, blurring of vision, double vision, difficulty in near vision, intolerance to light, seeing coloured halos, worsening vision and headache.

Frequency was recorded as follows,

Never=if symptoms did not occur at all.

Occasionally=if sporadic symptoms or once a week.

Often or always=2 or 3 times in a week or almost daily.

Intensity was recorded as moderate or severe symptom.

Total DES score was calculated by applying the following formula,

Score=$\sum_{i=1}^{16}(frequency\ of\ symptom\ occurence \times intensity\ of\ symptom)_i$,

Frequency: never=0, occasionally=1, often/always=2,,

Intensity: moderate=1, severe=2.

The overall assessment was obtained from the total score, recorded as the DES,

Score=$product\ of\ frequency \times intensity\ recorded,$

0=0; 1or 2=1; 4=2.

A person was considered to have digital eye strain, if the total score was ≥6 points.

DES scores were categorized as follows: mild DES score=6-12; moderate DES score=13-18; and severe DES score=19-32.

Ethical considerations

Ethical clearance was obtained from the institutional ethics committee of our institution (IEC No: EC/REV/2021/36) dated 1 October 2021. The information sheet regarding details of the study and data collection was given to the parents/guardians and children. Informed consent was obtained from the parents/guardians of all the study participants, before the start of the study as per the Declaration of Helsinki. The questionnaire was sent online and filled in by those who were willing to participate in the study. Strict confidentiality was maintained so that the information obtained, was not used for any purpose other than stated. The survey questionnaire which was translated from English to the local language (Malayalam) was sent to the respondents via Google form. The contact details (mobile telephone numbers/emails) of the participating children or their parents/guardians were confirmed by the school authorities for ensuring that the online Google forms were filled in only by the students and their parents/guardians and not by anyone else. The contact details of the principal investigator and co-investigator were given to the parents/guardians of the respondents so that their doubts/queries could be cleared.

After the survey questionnaire was returned to the investigators, the safety tips for children during screen use were sent to the parents and children as written recommendations to protect children from unhealthy use of digital devices and also to give suggestions on how to optimise the use of digital devices, in order to prevent DES. Advice regarding the 20-20-20 rule of taking frequent breaks in between the screen time and the need for regular monitoring of their eye-health was also given.

In this study, there was no known risk involved, no conflict of interest and no monetary benefits were given to the participants.

RESULTS

Socio-demography

In this cross-sectional study to assess the prevalence and associated risk factors of DES among school children, there were a total of 176 female study participants who were chosen from a randomly selected school in Adichanalloor panchayat of rural Kollam. Their age-range was 12-16 years and mean age was 13.98±0.96 years (Figure 1). Of the 176 respondents, 66, 52 and 58 students were from the 8th, 9th and 10th classes respectively.

Table 1: Pattern of digital device usage among study participants (n=176).

Category	Frequency	Percentage
Digital device used for online classes		
Computer	6	3.4
Laptop	7	4.0
Smart phone	159	90.3
Notepad/I-pad	4	2.3
Preferred digital device for online class		
Computer	10	5.7
Laptop	67	38.1
Smart phone	95	54.0
Notepad/I-pad	4	2.2
Distance of digital device viewing during online class (in inches)		
10-18	89	50.6
18-20	53	30.1
20-24	22	12.5
≥25	12	6.8
Duration of digital device use (before COVID-19 lockdown) (in hours)		
<1	118	67.0
1-2	40	22.7
2-3	11	6.3
3-4	7	4.0
≥5	0	-
Duration of digital device use (during COVID-19 lockdown) (in hours)		
<1	22	12.5
1-2	55	31.3
2-3	57	32.4
3-4	34	19.3
≥5	8	4.5
Daily television viewing time (in hours)		
1	90	51.1
1-2	60	34.1
>2	26	14.8
Playing games on smart phone daily (in hours)		
<1	153	86.9
1-2	14	8.0
>2	9	5.1

Table 2: Association between probable risk factors and DES (univariate analysis).

Category	DES frequency N (%)	No DES frequency N (%)	Significance
Age in years			
14-16	28 (15.9)	32 (18.2)	*OR=3.354 (1.703-6.604); p=0.001
12-13	24 (13.6)	92(52.3)	
Class studying			
8	13 (7.4)	53 (30.1)	*χ^2=10.099; df=2; p=0.006
9	13 (7.4)	39 (22.2)	
10	26 (14.7)	32 (18.2)	

Continued.

Category	DES frequency	No DES frequency	Significance
Digital device use			
Smart phone	48 (27.3)	111 (63.1)	OR=1.405 (0.436-4.531); p=0.781
Other digital devices	4 (2.2)	13 (7.4)	
Preferred digital device			
Smart phone	21 (11.9)	74 (42.1)	*χ^2=5.489; df=1; p=0.019
Other digital devices	31 (17.6)	50 (28.4)	
Viewing distance (inches)			
≤18	34 (19.3)	55 (31.3)	*χ^2=6.482; df=1; p=0.011
>18	18 (10.2)	69 (39.2)	
Duration of digital device use: COVID era (hour/day)			
>1	32 (18.1)	67 (38.1)	
<1	20 (11.4)	57 (32.4)	OR=1.263 (0.601-2.657); p=0.360
Duration of digital device use: pre-COVID (hour/day)			
>1	7 (3.9)	11 (6.3)	OR=1.837 (0.396-8.511); p=0.359
<1	45 (25.6)	113 (64.2)	
TV viewing time (hour/day)			
>1	29 (16.5)	57 (32.4)	OR=1.482 (0.773-2.843); p=0.235
<1	23 (13.0)	67 (38.1)	
Video game playtime (hour/day)			
>1	3 (1.7)	20 (11.4)	χ^2=3.141; df=1; p=0.085
<1	49 (27.8)	104 (59.1)	

Table 3: Determinants of DES (multivariate logistic regression analysis).

Category	Cut-offs	Adjusted OR	Adjusted OR 95% CI	P value
Age (years)	14-16 versus 12-13	0.244	0.117-0.508	0.000
Viewing distance (inches)	≤18 versus > 18	*2.762	1.331-5.731	0.006
Prefer to use smartphone	Smart phone versus other devices	*2.846	1.371-5.906	0.005

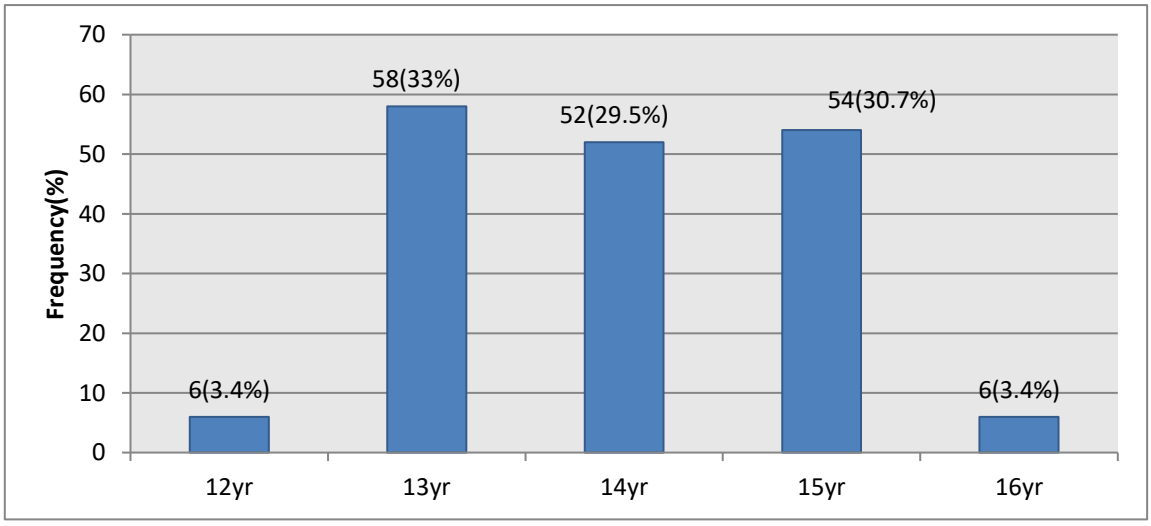

Figure 1: Age-wise distribution of respondents (n=176).

Prevalence of DES

The prevalence of DES in this study was 29.5% (95% CI=22.8-36.5%) among the 176 study participants. According to the DES Score guidelines, the cut-off point of >6 was taken as the score for diagnosing DES. Applying this score, 52 students were found to have DES in the present study.

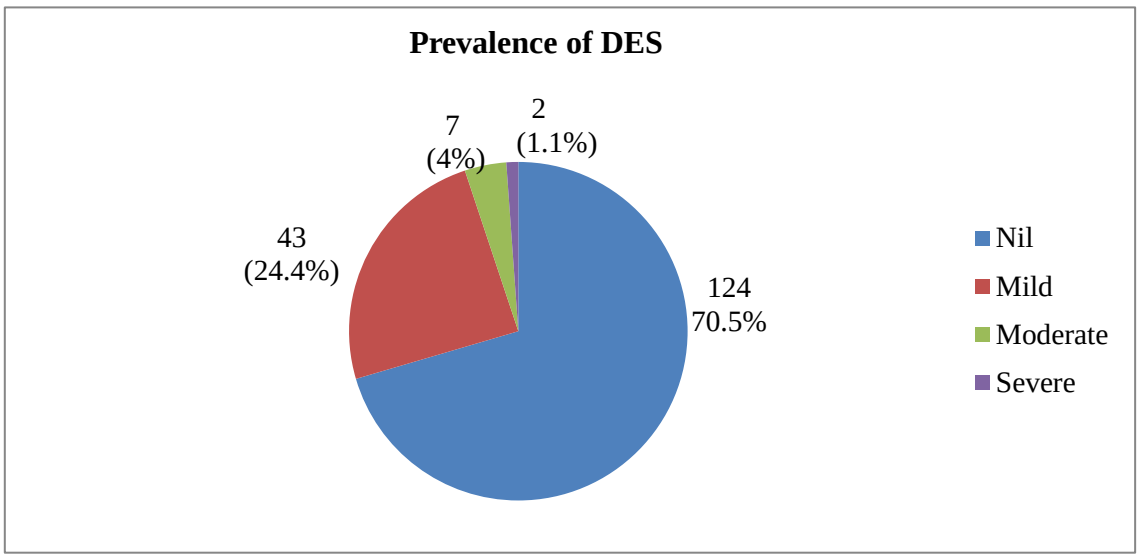

Figure 2: Grading and distribution of DES among respondents (n=176).

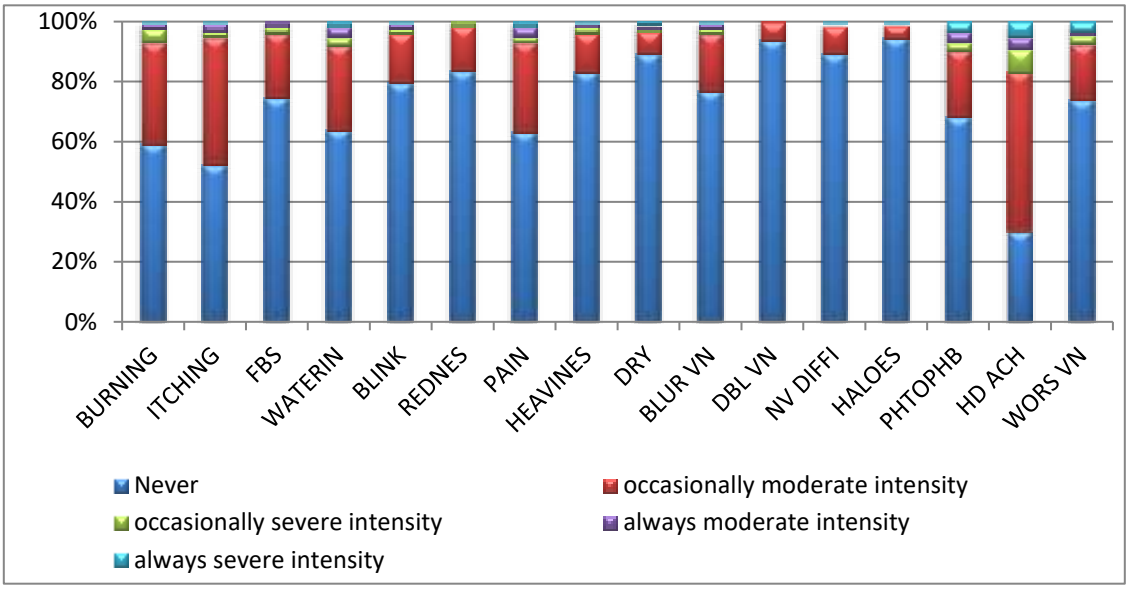

Figure 3: Pattern (intensity and frequency) of symptoms of DES among school children (n=176).

Those having DES were then graded into mild, moderate and severe DES categories, according to the frequency and intensity of their symptoms. Among the DES categories, the majority (n=43; 24.4%) of the respondents belonged to the mild grade of DES with a score of 6-12. Those with moderate DES (score of 13-18) constituted (n=7; 4%) while those who had severe DES (score of 19-32) consisted of only (n=2; 1.1%) of the study participants (Figure 2).

Pattern of use of digital devices

In this study, only 58 (33.0%) of the participants reported using the digital devices for more than an hour (1-5 hours) before the COVID-19 era, while during the COVID-19 pandemic, most of them (n=154; 87.5%) were using digital devices for more than an hour (1 to 5 hours).

All the respondents were attending online classes and of these, the most commonly used digital device was the smartphone which was used by most of the respondents (159, 90.3%) and it was also their most preferred digital device (n=95; 54%). The distance of digital device viewing during online classes was less than 18 inches among the majority (n=89; 50.6%) of the study participants. Daily television viewing and playing video games on smart phone were restricted to less than an hour among the majority of the study subjects (n=90; 51.1% and n=153; 86.9%) respectively. Before the COVID-19 lockdown, most of them (n=118; 67%) were spending less than an hour on digital devices but during the COVID-19 lockdown, an overwhelming majority (87.5%) have been using digital devices for more than an hour (1-5 hours).

Univariate analysis

In the univariate analysis, the association between risk factors and DES were studied and it was found that the statistically significant risk factors associated with DES were age of the children, the class in which they were studying, preference for using smartphone over other devices and the distance of digital device viewing. The risk of DES was 3.354, (95% CI=1.703-6.604) times higher in the older age groups (>14 years) and this was found to be statistically significant (p=0.001)). Children studying in the 9th and 10th classes had 10.009 times greater risk of DES than those in the 8th standard and this was statistically significant (p=0.006). Those using smartphone as their preferred digital device for online classes were 5.489 times more at risk than those using other digital devices and this was statistically significant (p=0.019). Those using digital devices at a distance of <18 inches were 6.482 times at higher risk of DES than those who used a viewing distance of >18 inches and this was also found to be of statistical significance (p=0.011).

Multivariate analysis

In the multivariate analysis of the present study, the independent risk factors that remained significantly associated with DES (after adjusting for all known risk factors) were the viewing distance of digital devices at less than 18 inches (p=0.006) and using the smartphone as the most preferred digital device during online classes (p=0.005).

Pattern (frequency and intensity) of symptoms of DES

Among the symptoms of DES, reported in the present study, headache (n=125; 69.9%) was the most common, followed by itching sensation (n=84; 47.7%), burning sensation (n=72; 40.9%), eye pain (n=65; 36.9%) and watering of eyes (n=64; 36.4%), while the least common symptoms were seeing haloes around objects (n=10; 5.7%), double vision (n=11; 6.2%), dry eyes (n=19; 10.8%) and difficulty in near-vision (n=20; 11.4%).

DISCUSSION

Technology had become the only tool for people to interact, communicate and continue their responsibilities. Human interaction had become virtual in the form of online meetings, audio, video conferencing, recreational activities like online gaming, blogging, social networking resulting in rapid upsurge in increased digitalization in every aspect of human life. Different educational platforms like Google classroom, Zoom, Microsoft teams were now being used by various educational institutions around the globe.[5] The increased use of digital devices by school children as they were at home 24×7, during this pandemic, brings a new challenge of digital eyestrain at an early age.[6]

In the present study, the prevalence of DES was 29.5% (DES score >6) among the study participants aged 12 to 16 years and studying in the 8th, 9th and 10th standards of an aided school in a rural area of Kollam district in Kerala. This was consistent with the finding of a previous study in which the prevalence of DES in the community was found to be ranging from 22.3% to 39.8%.[9] Various studies have estimated the prevalence of DES to be in the wider range of 25% to 93%.[10,11] A systematic review and meta-analysis on the prevalence of DES in children below 18 years showed a pooled prevalence of 19.7% (12.4-26.4%).[12,13] A cross-sectional study of adolescent school children aged 11-17 years in Chandigarh in 2016 found the prevalence of DES to be 18%.[6] However, a high prevalence of DES ranging from 50-75% had been recorded in various studies.[14-22] There were other studies with an even higher prevalence ranging from 75-95%.[23-26] The risk of DES was seen to be increasingly associated with the increasing age group of the respondents such as in those studies involving older children, college students, young computer workers and adults, who used digital devices for most of their work. This showed that the prevalence of DES varies in different age groups exposed to differing duration of use of digital devices. Compared to these studies, the present study included younger children (mean age 13.98±0.96 years), the majority of whom were using digital devices for a relatively shorter duration of time and hence the lower prevalence of DES. Therefore even though DES was found to be statistically significant with increasing age of the respondents in the univariate study, it was not significant in the multivariate analysis, due to the fact that age distribution of the respondents was not uniform and most (65.9%) of respondents were in the younger age group (12-13 years).

In this study, it was seen that those with mild DES constituted the majority 43 (24.4%) of respondents with DES. Among the rest of the children with DES, only a few, 7 (4%) and 2 (1.1%) of them had moderate and severe DES respectively. This finding was comparable to various studies, where among those of the respondents with DES, majority had mild DES, while moderate and severe DES were found in fewer study subjects.[7,14,20] This indicated that DES was an emerging problem which had to be tackled on an urgent basis now, before it became severe and led to visual complications in young children later on.

The most common digital device used by the children in the present study was the smart phone and their preferred use of the smart phone was found to be a risk factor that was statistically significant for DES in both the univariate and multivariate analyses of the present study (p=0.005). Similar finding was seen in most of the other studies.[7,14,29-32] This can be explained by the fact that using smartphones continuously led to a decrease in the blink rates and thereby precipitated the problem of dry eyes which was an important factor in the occurrence of DES.[2,3,9] These devices caused harm by emitting short high energy waves that can penetrate the eyes and can

eventually contributed to a photochemical damage to the retinal cells, making the person vulnerable to a variety of eye problems ranging from dry eye to age related macular degeneration.[2,3] As children in the older age groups spend more time using the smartphone, this may have resulted in an increase in the prevalence of DES in the higher age groups.[6,14]

The viewing of digital devices at a distance of less than 18 inches was also found to be a statistically significant risk factor of DES in both the univariate and multivariate analyses of the present study (p=0.006). This finding was observed in various studies.[18,24,25] Due to the small sized screens of the smart phone, it had to be viewed at a closer distance and this would accelerate the occurrence of DES in the children. The lower prevalence of DES in this study may also be due to the fact that even though the majority (n=153, 86.9%) of the respondents played video games, it was for less than an hour daily and thus eye strain symptoms had not affected the study subjects to a considerable extent, when compared to other studies where children played video games for longer period and the prevalence of DES was higher.[7,13,14] In this study, the duration of use of digital devices in total was about 1-3 hours for the majority of respondents while in most other studies, it was more than 5-6 hours.[15,24-31,33] Hours of exposure to digital devices for online classes and other associated indoor activities were greater during the COVID-19 pandemic period than in the pre-COVID era as there were restrictions for outdoor activities during the pandemic. This can be attributed to the lockdown period, when children were not only attending online classes from home, but were doing their homework also online, in addition to their use of digital devices regularly for leisure purposes. Similar findings were seen in various studies.[7,17-22,25,28-32]

In the present study, the most common symptoms of DES was headache (n=125; 69.9%) followed by itching of eyes (47.7%). Headache was the most commonly reported symptom in various studies.[9,18,20,21,25,27] The symptoms least reported in our study were seeing haloes around objects and double vision and their occurrence was minimally seen in a few studies.[7,9,26,31] The frequency and intensity of DES symptoms were generally found to be varying across studies because of their relatively subjective nature, especially as perceived by children.

The present study had highlighted some of the significant and independent risk factors of DES such as the preferred use of smartphone among school children, during the online classes and the short viewing distance from the digital screen. These unhealthy habits of digital device usage, which were being practised by school children were to be prevented at the earliest, by increasing the awareness about DES among them and among the general public at large. This study was contributing to the increasing evidence in medical literature of the association between DES and inappropriate use of digital devices which were independent risk factors of DES, especially in children.

Limitations

This study was conducted among school children in a rural area of Kollam and therefore the results may not be generalised to school children studying in urban localities and elsewhere in Kerala.

CONCLUSION

Our study has assessed the prevalence of DES and has highlighted some of the independent risk factors of DES such as the preferred use of smartphones among the majority of respondents and the unhealthy practice of viewing the digital devices at very short distances of <18 inches. Further evidence-based research is needed to fully understand DES and its implications on the eye health. There should be a concerted effort by doctors (general physicians, family doctors, paediatricians, ophthalmologists in the outpatient departments), optometrists in the schools, health workers in the field, school authorities and policy planners to increase awareness among the school children, their parents and teachers about DES and its associated adverse health issues on children. This would empower the parents and teachers to monitor and optimise their children's use of digital devices, so as to tackle the issues associated with DES at the primary level of prevention.

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